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Introduction

The Valley Hospital continues to expand their work on medical error reduction by implementing a Mobile Equipment Tracking system utilizing a real time location system along with radiofrequency tagging. The initial phase of the project built a hospital-wide infrastructure of RTLS hardware and defined the desired zone-based configuration needed for adequate tracking. AgileTrac software was then installed to pass the milestone marks to disparate systems for the purpose of location, preventative maintenance or repair of tagged equipment. The proposed research project intends to demonstrate the effectiveness of using middleware to homogenize data produced by varied real time location system (RTLS) platforms for consumption by a common user interface and application. The project is intended to lead the way to further study of the application throughout the hospital in the inpatient and peri-operative setting tagging other assets as well as patients and caregivers.

System Equipment Tracking

Background: The Valley Hospital has implemented a real time location system (RTLS) to provide asset locations for determining equipment utilization and improving turn-around time for equipment maintenance. It is The Valley Hospital's intent to use the system to manage patient flow in a future phase. This system has been implemented in a phased approach to accommodate the absorption of the technology and integration with existing workflow processes and computerized information systems. The Hospital has implemented a Mobile Equipment Tracking Team to identify key opportunities to drive operational efficiency, improve patient satisfaction, and increase asset utilization. The RTLS industry contains many proprietary, vendor-specific hardware and software platforms which are designed to 1: promote a particular technological development agenda, or 2: overcome a perceived or actual environmental characteristic. This project is not intended or designed to promote or advocate for one technology over another, but to provide a framework where multiple, disparate RTLS technologies can coexist in the same ecology and allow their disparate outputs to be merged into a cohesive, organized flow of information. This research project demonstrates the effectiveness of using middleware to homogenize data produced by varied RTLS platforms for consumption by a common user interface and application.

The present phase of the project is tracking intravenous infusion pumps, sequential compression devices, pulse oximeters, external pace makers and beds. Subsequent phases of the project will include Patient flow, clinical process management to improve critical or time-sensitive events, Mobile Equipment Tracking in the Perioperative Suite, and expansion of the current Mobile Equipment Tracking to include beds and other key assets.

The system design has shown that diverse, disparate, wireless real-time location tracking technologies can co-exist in a single environment and that the positional information they provide can be merged into a single set of data outputs that can provide a single pane-of-glass view of the real-time location of materiel assets, clinical process management that these data outputs can also be sent to ancillary asset and workflow systems based on their parochial interests.

1. Technical Objectives:

- a. General Electric Healthcare's AgileTrac solution was selected as the Real-Time Location System (RTLS) implemented at The Valley Hospital. This implementation provides relevant (room-level or bay-level) positional information for tagged movable assets in patient care areas. The system also provides zone-level positional information for all other areas of the Hospital. Ensure the solution complies with all RF transmission guidelines to avoid interference with Hospital's wireless communication systems and clinical modalities.
- b. The RTLS Server homogenizes the output from the RTLS System for consumption by heterogeneous computerized information systems. The middleware application is scalable to allow for inputs from multiple, disparate,

RTLS systems as well as multiple, diverse, parochial information systems. The middleware application is compatible with multiple interface specifications for heterogeneous computerized information systems. The middleware application contains user-configurable, rules-based workflow and notification components to guide information delivery and notification processes for key events.

- c. The Hospital's bio-medical device asset management system is interfaced to the RTLS System. This interface provides real-time positional data which is consumed and processed by the asset management system to facilitate asset location for any device needing repair or preventative maintenance.
- d. The Hospital's Facilities Department's asset management system is interfaced to the RTLS System. This interface provides real-time positional data which is consumed and processed by the asset management system to facilitate asset location for any device needing repair.
- e. RTLS has been installed through The Valley Hospital for positional reference of materiel assets throughout the campus. The system provides zone-based coverage for all areas of the hospital. The system provides relevant, room-level, positional information for key areas within the patient care units and other designated areas.
- f. The Valley Hospital will identify opportunities to leverage the use of the RTLS Server rules to enhance patient throughput initiatives and other operational efficiencies through the improved utilization of materiel assets, coordinated event alerting based on key relevant positional triggers to improve workflow processes in a later phase of the project.

2. Key Research Accomplishments:

- a. 2010 January (Duration: 8 months) – System Selection Process
 - i. Evaluate and select Real-Time Location System technology
 - ii. Evaluate and select RTLS Server to provide compatibility for multi-vendor RTLS and legacy computerized information systems.
 - iii. Process order for RTLS and RTLS Server software, RTLS hardware, server hardware and required interface software for legacy computerized information systems.
- b. 2010 August (Duration: 8 months) – System Ordering and Installation
 - i. Install hardware for RTLS.
 - ii. Test and refine radio-frequency (RF) coverage to meet desired zone-based configuration in Emergency Department. Ensure RF design is benign and introduces no negative impact to existing, in-use, RF services.
 - iii. Test and refine radio-frequency (RF) coverage to meet desired zone-based configuration in Perioperative Suite. Ensure RF design is benign and introduces no negative impact to existing, in-use, RF services.
 - iv. Test and refine radio-frequency (RF) coverage to meet desired zone-based configuration for departmental zones. Ensure RF design is benign and introduces no negative impact to existing, in-use, RF services.
 - v. Test and refine relevant-location solution (infra-red, ultrasound, etc) to meet desired positive location identification in Patient Care units and other areas of interest outside the Emergency Department.

- c. 2011 February (Duration: 2 months) – Modification of legacy systems
 - i. Modify legacy biomedical equipment asset management system to allow for real-time location of tagged assets.
 - ii. Modify legacy Facilities Department equipment asset management system to allow for real-time location of tagged assets.
 - d. 2011 March (Duration: 2 months) – System configuration and documentation
 - i. Process RFID tags and enter into asset management system. Associate tags in asset management system.
 - ii. Install RTLS Server hardware and software.
 - 1. Configure zones
 - 2. Configure patient locations
 - 3. Configure asset locations
 - 4. Configure notification and alerting rules
 - 5. Configure and document workflow processes for patient tagging
 - 6. Configure and document workflow processes for asset tagging
 - 7. Configure and refine relevant information-sharing needs for patient tracking.
 - 8. Configure and refine relevant information-sharing needs for asset tracking.
 - 9. Test interface between legacy Facilities Department device asset management system and RTLS Server.
 - 10. Test interface between legacy biomedical device asset management system and RTLS Server.
 - e. 2011 March (Duration: 1 months) – Training
 - i. Train Biomedical Engineering personnel on RTLS Server use and changes to workflow
 - ii. Train appropriate Facilities Department personnel on RTLS Server use and changes to workflow
 - f. 2011 April (Duration: 1 month) – System Introduction for Patient Care Services
 - i. Introduce RTLS Server and asset management process into production environment. Observe and refine workflow, notification and information processing rules.
3. **Military Significance:** Creating a method for homogenizing location data from disparate RTLS systems that will allow multi-vendor sourcing of hardware and accelerate the adoption of multi-site implementations. Current manual asset management processes often cause insufficient availability of assets, labor-intensive physical inventories, shrinkage and inadequate asset maintenance as well as uncertainties in readiness status, which can impact the critical patient care issues. Real-time asset management systems based on RTLS technology can reduce inventory requirements, ensure adequate inventory to meet operational demands, minimize shrinkage of assets, and improve productivity and accountability. The technology platform being introduced will enable these benefits and provide an open framework on which vendors can create solutions.

4. The military already has disparate RTLS systems actively deployed. This project would allow for the continued selection and implementation of diverse RTLS technologies that are designed to meet the environmental and process requirements while enabling cross-departmental information sharing and more effective asset mapping for logisticians.
5. **Public Purpose:** This project provided a framework for product evaluation and selection by organizations wishing to invest in RTLS technology but confused by the diverse solutions and lack of standardization. Our project will afford organizations the opportunity to select the most appropriate RTLS technology solution(s) for their environment while allowing for information-sharing requirements to parochial, legacy information systems. Wifi-based RTLS systems could coexist in the same organizational ecology as RF/IR systems based on the department or unit's needs. The positional information available from each RTLS would be processed by the centralized RTLS Server and integrated through its rules engine to spawn correlated event notification to interested parties and present a holistic view of managed assets.

In addition to the technical application advancement, the ability of the system to generate milestone marks as well as location of patients and assets has proven to be a tremendous assist in gaining healthcare efficiency, increased patient satisfaction and enhanced patient safety.

Healthcare organizations struggle with the ability to track their assets for example, I.V. infusion pumps. The ability to readily locate pumps at the moment they are needed is ensuring the patient is receiving their medication therapy in a timely manner, which is an important patient safety issue. The fact that the employee didn't have to spend an excess amount of time to locate the pump is an employee satisfier. The system's ability to track assets has helped to purchase the right amount of pumps, creating cost savings. Continuation of the implementation in later phases will provide the ability to track patients through their steps in the care process using a real time location system will help healthcare organizations learn what processes can be improved upon to increase efficiency and provide timely, safer care for patients. The milestone marks generated by the RTLS will be far more objective allowing benchmarks to be established so healthcare organizations can use them in their process improvement activities. In so doing, care will be delivered to patients in a way that will minimize risk, minimize bottle-necks in the system and hasten diagnosis and start of treatment to the patient. In addition, creating capacity for staff to spend more time at the patient's bedside. Collectively, these enhancements will create safe, patient-centered, effective, efficient and timely care. These elements reflect the vision of health care for the American public written in the Institute of Medicine's report, "Crossing the Quality Chasm."

6. **Methods:** The testing methodologies used confirmed the accuracy of the solution, displaying the asset on an electronic map that consistently corresponds to a real-life physical location. The process for vetting the solution required repeatable results establishing positive identification that an identified asset's RTLS Server location matched its real-life, physical location whether it be zone-based or room-based level of granularity. The test was performed using a tagged asset using the positional reference software map contained in the RTLS Server. The testing method was deemed successful when it was confirmed by a statistically significant number of occurrences that the tagged asset is displayed within 3 feet of its "real life" location and in the zone-based coverage areas as well. Further testing included confirmation that interfaced heterogeneous information systems include the appropriate location values as are observed within the RTLS Server. This location information proved to be consistent and was updated in the heterogeneous information system within 300 milliseconds of a location-change event generated from the RTLS.

The statistical analysis utilized was the Kappa test for agreement between the electronic maps versus the real life position. The measurement was graded on two levels- either they agree (within 3 feet of position) or they don't agree (greater than 3 feet difference). The Kappa statistic will describe the level of agreement with Kappa. (-1.0 being total disagreement and Kappa= 1.0 being perfect agreement). An agreement level would be recognized at least 0.95. It has been determined that at least 200 observations would need to be made to highly correlate the map position to the real life position.

7. **Reportable Outcomes:** Received contract through USA Medical Research Acquisition Activity dated 08 Sept 2011 for 24 month period of performance to continue to advance the technology and further the research utilizing the RTLS system.
8. **Conclusion:** The system design has shown that diverse, disparate, wireless real-time location tracking technologies can co-exist in a single environment and that the positional information they provide can be merged into a single set of data outputs that can provide a single pane-of-glass view of the real-time location of materiel assets, clinical process management and that these data outputs can also be sent to ancillary asset and workflow systems based on their parochial interests.

The findings in the first phase of this research leads the investigator to a reasonable assumption that the RTLS system will perform at the same level, through scalability by tagging additional assets and interfaces to additional disparate systems. The streamlining of clinical processes in tandem with the asset tagging has resulted in increased end user satisfaction as evidenced by finding equipment in the expected storage area, available and ready for use. End user satisfaction is further enhanced by the ability to have ready access to an electronic tool to locate and account for equipment. The value added is the end user has developed trust in the process which has resulted in greater compliance with steps in process design.

This base of knowledge will be used to continue the research to open tagging to a vast number of assets which will be a load test on the system. Another opportunity to be explored is tags produced by other manufacturers or with special properties such as, the ability to be resistant to chemical and moisture penetration from sterilization procedures.

The investigator hopes to ride the success of the user acceptance of the technology when the research moves toward tagging people. Lastly, the integration of clinical process with technology for the enhancement of patient safety will be a significant part of the research in the next phase.

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BIOGRAPHICAL SKETCH

Provide the following information for the key personnel listed on the budget page.

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New Jersey Institute of Technology Newark, New Jersey	MS	2	Human Resource Management

RESEARCH AND PROFESSIONAL EXPERIENCE: Concluding with present position, list in chronological order, previous employment, experience and honors. Include present membership on any Federal Government public advisory committee. List in chronological order, the titles, all authors and complete references to all publications during the past 3 years and to representative earlier publication pertinent to this application. If the list of publications in the last 3 years exceeds 2 pages, select the most pertinent publications. *PAGE LIMITATIONS APPLY. DO NOT EXCEED 3 PAGES FOR THE ENTIRE BIOGRAPHICAL SKETCH PER INVESTIGATOR.*

Present Position:
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Director of Clinical Systems Quality Improvement
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RESEARCH AND PROFESSIONAL EXPERIENCE (CONTINUED). PAGE LIMITATIONS APPLY. DO NOT EXCEED 3 PAGES FOR THE ENTIRE BIOGRAPHICAL SKETCH PER INVESTIGATOR.

Accomplishments:

Chairman of the Performance Improvement Committee of the NJHA, Quality Institute

Member of the Technology Committee of the NJHA, Quality Institute

Managing the operations and clinical performance of a progressive pharmaceutical service

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Board of Trustees at The Valley Hospital

Member of the Quality Improvement Advisory Board, The Department of Health, State of New Jersey. Appointed by the Commissioner of Health, State of New Jersey

Principal Investigator for Medical Error Reduction Study

Presentations:

"Partnering With Your Patients- A Way to Reduce Patient Identification Errors," Institute for Healthcare Improvement National Congress, 5/96

"A Hospital's Working Model of a Medication Management System," ASHP Annual Meeting 6/2000, ASHP Midyear meeting 12/2000.

"Reducing Specimen and Medication Error with Hand-held Technology,"
Health Information Management and Systems Society 2001 Annual Conference, 2/2001

"Patient Safety, One Hospital's System-wide Approach to Reducing Medical Errors," Joint Commission 2001 National Conference, 11/01

Publications:

Mutter M., Bologna L., Hardy G., "Reducing Specimen and Medication Error
With Hand-held Technology," Health Information Management
And Systems Society. Winter 2002, 16:1: 65-70.

Mutter M., "Our Hospital's Journey Towards Reducing Medication Errors,"
Joint Commission Journal on Quality Improvement, June 2003, 29:6:279-288.